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Application Report
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Using Voltage Supervisor for Input Over-Voltage Protection in LED Drivers

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ABSTRACT

Lighting electronics meant for AC-DC applications tend to get subjected to input line variations leading to sustained over-voltage on the driving circuitry. Metal oxide varistors (MOV's) meant for suppressing the transients fail at such sustained over-voltage leading to system failure and hence the need for incorporation of separate circuitry for the Input Over-Voltage Protection. The TLV809 family of supervisory circuits that provide circuit initialization and timing supervision, primarily for DSPs and processor-based systems can be used for the Over-Voltage Protection in LED drivers and other AC-DC power supply applications.

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1 Introduction

The TLV809K33 is a family of ultra-low current supply voltage supervisors (SVS) that monitor a single voltage rail. Because this device is a fixed-voltage monitor, it is typically configured as shown in Figure 1. During power-on, $\overline{RESET}$ is asserted when the supply voltage (V_{DD}) becomes higher than 1.1 V. Thereafter, the supervisory circuit monitors V_{DD} and keeps $\overline{RESET}$ active as long as V_{DD} remains below the threshold voltage V_{IT}. An internal timer delays the return of the output to the inactive state (high) to ensure proper system reset. The delay time (td (typ) = 200 ms) starts after V_{DD} has risen above the threshold voltage, V_{IT}. When the supply voltage drops below the V_{IT} threshold voltage, the output becomes active (low) again. No external components are required. All the devices in this family have a fixed sense-threshold voltage (V_{IT}) set by an internal voltage divider.

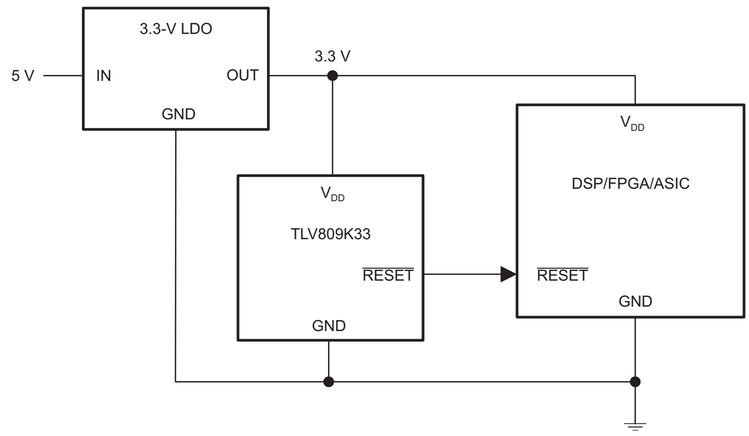

Figure 1. Typical Application

2 Functional Block and Timing Diagram

The TLV809 family of voltage supervisors has an internal Schmitt trigger that provides hysteresis of 30 mV (min) to 60 mV (max) to avoid false trigger due to V_{DD} voltage fluctuations. The V_{DD} voltage fluctuations become more pronounced and more susceptible to false trigger when it is derived from the input AC. Therefore, an internal hysteresis makes the device suitable for the shutdown in case of Input Over-Voltage in the AC-DC LED drivers. Figure 2 shows the functional bock diagram of TLV809.

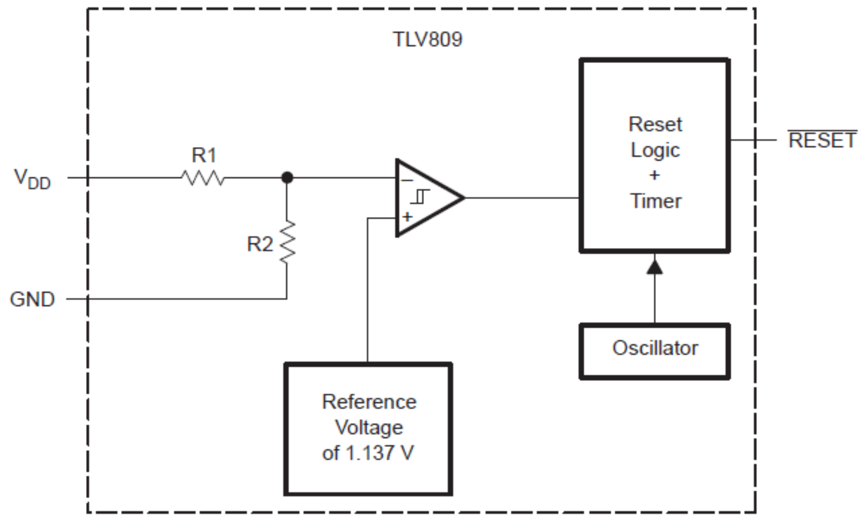

Figure 2. Functional Block Diagram

Figure 3 shows that state change of the $\overline{RESET}$ incorporates an internal delay of 200 ms and the undefined behavior of the Reset output for V_{DD} < 1.1 V.

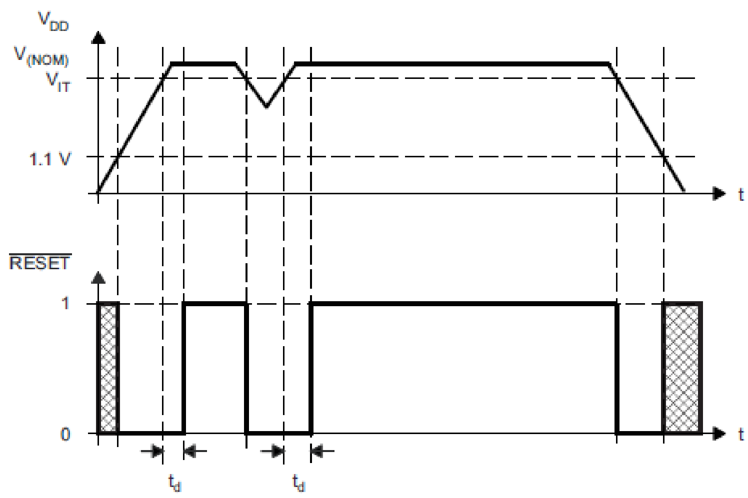

Figure 3. Timing Diagram

3 Input Over-Voltage Protection in LED Drivers

TPS92210-based LED drivers can be prevented against Input Over-Voltage by an external shutdown/retry by pulling VCG pin to ground. Voltage on the VCG is internally clamped; the clamp level varies with the operating conditions. In normal use, VCG is current fed with the voltage internally clamped. The gate of the HV Mosfet is held at a constant DC voltage using the VCG pin. It is shunt regulated to 14 V during normal operation and regulation is increased to 16 V during fault, UVLO and start-up conditions. When pulled low (below 9 V), the VCG pin pulls down the gate of the external HV Mosfet disabling the PWM action.

4 Conventional Approach

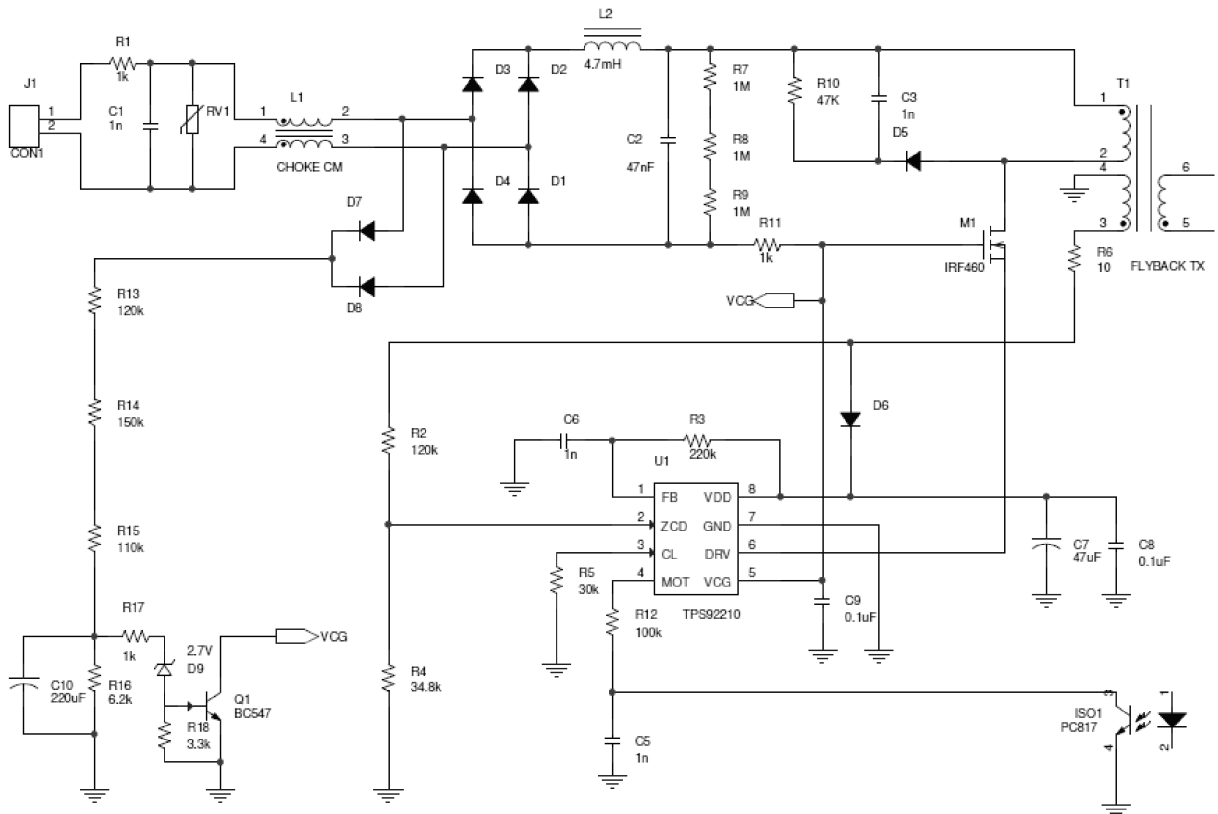

Figure 4. Input Over-Voltage Protection With Conventional Approach

The VCG pin can be pulled low by turning ON an NPN transistor with Zener diode at the base. Once the rectified AC line voltage exceeds the set point, the Zener diode conducts and turns ON the transistor that pulls down the VCG pin.

Disadvantages with the approach:

- Need of a higher capacitance C10 (220 µF) to make the Zener diode to conduct and turn ON Q1.
- The set point for the input over the voltage cut off can not be precisely fixed as it depends on the breakdown voltage of the Zener diode. The Zener diodes have a tolerance of 5% (min) to 10% (max), which translates to shifting the AC line cutoff voltage set point.
- The AC line voltage hysteresis attainable with the above approach is more than 30 V, which is on a higher side as C10 (220 µF) in parallel to R16 (6.2k) takes more time to discharge.

5 Proposed Approach

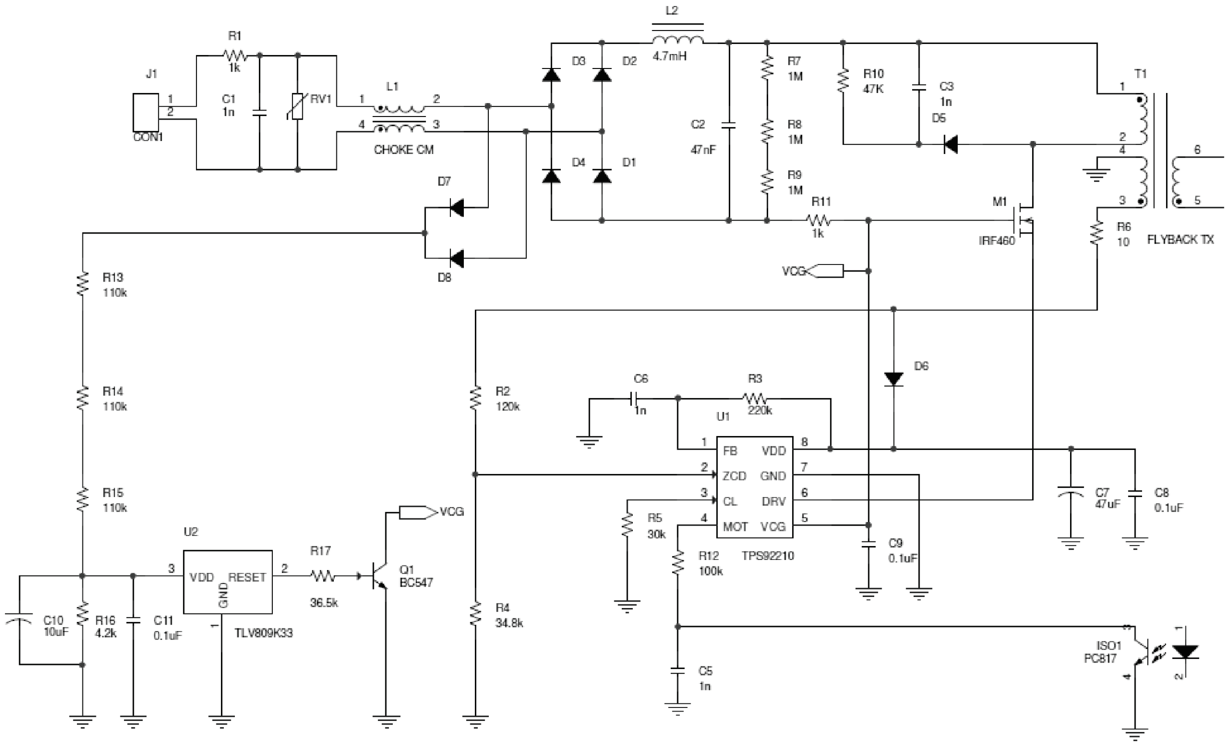

Figure 5. Input Over-Voltage Protection With Voltage Supervisor

The disadvantages with the conventional approach mentioned in Section 4 can be easily overcome using the voltage supervisor TLV809K33. The use of the TLV809K33 allows the use of smaller capacitor C10 (10 µF) as it requires only the voltage reference for the RESET output state change from low to high. The TLV809XX has built-in rejection of fast transients on the V_{DD} pin. Transient rejection depends on both the duration and amplitude of the transient. Transient amplitude is measured from the bottom of the transient to the negative threshold voltage (V_{IT-}) of the device, as shown in Figure 6.

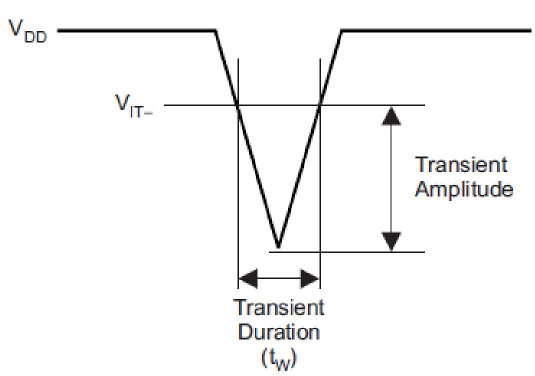

Figure 6. Voltage Transient Measurement

The TLV809XX uses a unique sampling scheme to maintain an extremely low average quiescent current of 150 nA. The TLV809XX typically consumes only about 100 nA of dc current. However, this current rises to approximately 15 μA for around 200 μs while the TLV809XX samples the input voltage. If the source impedance back to the supply voltage is high, then the additional current during sampling may trigger a false reset as a result of the apparent voltage drop at V_{DD}. For high V_{DD} source or trace impedance applications, it is recommended to add a small 0.1-μF bypass capacitor near the TLV809XX V_{DD} pin. This bypass capacitor effectively keeps the average current at 150 nA and reduces the effects of a high-impedance voltage source The voltage supervisor pulls the RESET output high once the V_{DD} voltage crosses the specified threshold (2.93 V for TLV809K33) after a delay of 200 ms, which ensures precise AC cutoff set point. The inbuilt hysteresis of 40 mV avoids false trigger and provides AC line Hysteresis of around 10 V, which is good enough for lighting applications.

The transistor Q1 (BC547) in Figure 5 can be replaced by Signal Mosfet 2N7002 and used for pulling down the VCG pin. The use of signal Mosfet reduces the dependency on the input gate capacitance (Ciss) of the external HV Mosfet (M1).

The input over voltage shutdown used for the TPS92210-based LED driver can also be implemented for other AC-DC power supply applications requiring cutoff at higher AC line voltages.

6 References

- *TLV809J25, TLV809L30, TLV809K33, TLV809I50 3-Pin Supply Voltage Supervisors Data Sheet* (SLVSA03)
- *TPS92210 Natural PFC LED Lighting Driver Controller Data Sheet* (SLUS989)

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